Spatial impacts and the characterisation of resource use in a heterogeneous landscape

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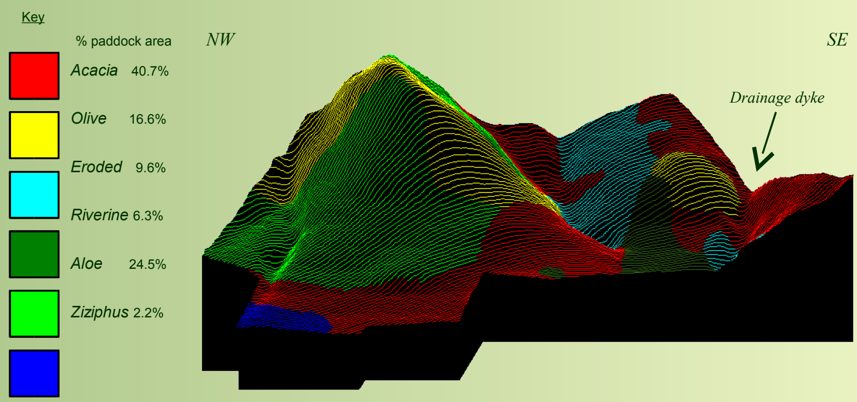
Introduction

Highly spatially variable environments pose animals with diet selection decisions that need to account for the patchy nature of their resource. Improved rangeland management would result from being able to predict patterns of animal utilisation of such vegetation. Whilst progress is being made in the comprehension of large scale influences (*e.g.*, location of drinking water, landscape topography), little is known about how these integrate with smaller scales. It is likely that animals view landscapes in differing ways, depending on the scale that processes operate. Identification of the appropriate scale at which a species is affected by the spatial heterogeneity of a resource requires characterisation of the resource spatial structure, independent of our own biases. We tend to view landscapes in terms of vegetation communities, whilst the appropriate unit for animal perception remains unclear. This poster describes a study of foraging behaviour carried out as a method by which to associate animal activity with space use as an independent estimate of spatial heterogeneity.

Method

Trials were carried out between 08/06/98 and 21/07/98 in a 19.8ha section of the Lovedale Camp, on the research farm belonging to the University of Fort Hare, in the eastern Cape, South Africa (32°47'S, 26°51'E). The long-term (1970-1996) mean annual rainfall is 620mm of which two-thirds typically falls between October and April. Only 347mm fell during 1997/8, the year preceding the experiment.

The experimental paddock was situated NW to SE across the undulating south escarpment of Sandile's Kop, an approximately 150m-high outcrop (649.4m a.s.l.). The slope of the scarp was steepest at its NW end (20-40°) and shallowest at its SE end (5-20°). Loam soils derived from underlying shale rock were punctuated by a dolomite dyke which ran the length of the paddock, parallel to the slope, and a drainage channel which cut the SE end of the paddock, perpendicular to the slope.



Experimental paddock digital elevation model constructed from a contour plot used in conjunction with a map of plant communities showing the community types present and the percentage contribution to the paddock area.

Animals

A mixed herd of approximately 120 Nguni and Boer goats were used from which 30 individuals were marked for identification. During the course of the 6 weeks of trials, the herd was introduced into the paddock at the same entry point each day and allowed to range freely until collection, typically 6 hours later, in total accumulating an estimated 260 grazing hours per individual.

On 14 days during this period continuous animal locations for the marked individuals were recorded using a Global Positioning System (GPS).

Concurrent with the measurement of an animal location, diet selection was also recorded. The duration of feeding activity was taken as the interval between the times that were automatically associated with the GPS recordings. This is based on the assumption that the previously recorded time was an unbiased estimate of the commencement of feeding by the next animal yet to be recorded.

Diet selections and non-feeding activities (locomotive and sedentary) were recorded for all 30 experimental animals at 5 minute intervals throughout the day. In total, 118 theodolite measurements, 1630 GPS measurements, 1748 diet selections and 19930 activity observations were collected.

Vegetation

The vegetation type may be described as False Thornveld (Acocks, J.P.H., 1988, *Veld types of South Africa*. Memoirs of the Botanical Society of South Africa 57).

Phytosociological communities were identified from patterns of bush canopy cover visible in an aerial orthophotograph in combination with prior knowledge of vegetation distribution. 6 main community types were identified (*above*). Species composition was recorded, ranked by contribution to aerial cover, in 50 1x1m quadrats randomly located throughout the paddock

Animal impacts

Defoliation impacts were assessed midway through (Survey I), and at the end (Survey II) of the experiment period. A tape was used to lay 20, 50m transects, spaced 10m apart, parallel to the hill slope, on a consistent 1:4 incline. The transect ends were located using the GPS. The position of each individual shrub/tree making contact with the tape was recorded along with an assessment of defoliation damage (removal of total available browse material) up to 1.5m in height, being the typical maximum extent for goats.

Defoliation was scored using a 5-point scale as follows: 0=0%, 1=1-10%, 2=11-25%, 3=26-50%, 4=51-75% and 5=76-100%. The grass layer associated with each tree scored in this way was taken as the average of four pasture disk meter measurements, each made a metre distance from the tree trunk along a cardinal bearing.

RESULTS and ANALYSES

Relating animal activity to defoliation impact

●Browsing accounted for 97.5% of the total feeding time recorded.

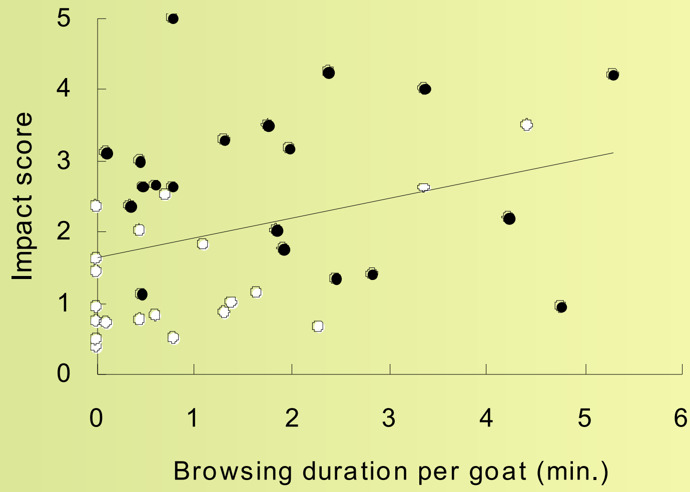
●The average time spent browsing at a feeding station ranged between 29.4 and 60.6 seconds. Average grazing activity persisted for 30.8 seconds per individual (standard deviation 46.0 seconds).

●Foraging time and defoliation impact scores both decreased with distance upslope prior to Survey I, and up to Survey II. The total minutes of foraging time accumulated for each transect before Survey I (x) showed a good correlation with the transect average defoliation impact (y) scored during Survey I ($y=5.11x+2.13$, $R^2=0.4$, $F=10.91$, $P<0.01$).

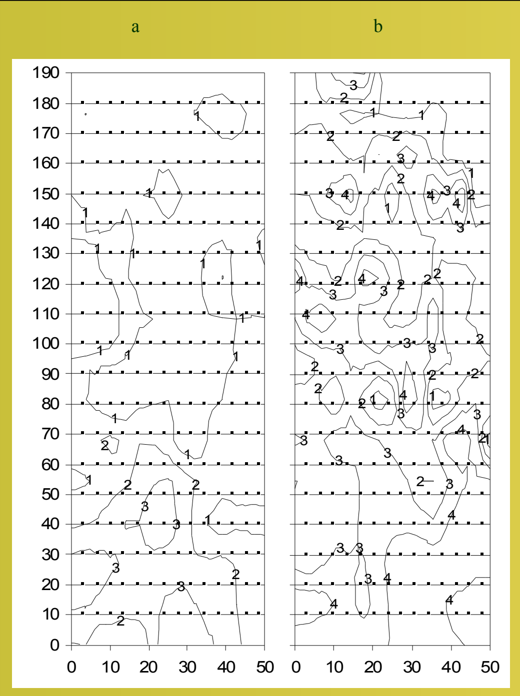
●An Olmstead-Tukey Corner Test of Association showed that defoliation impacts accumulated since Survey I were positively related with accumulated foraging time (Quadrant sum=20.0, $P<0.005$).

●Overall, defoliation score (*y*) was related to minutes of browsing time spent by a goat at each transect distance (*x*) by $y=0.28x+1.63$ ($R^2=0.12$, $F=5.12$, $P<0.05$; *right*).

●The overall average of 38.7 seconds (standard deviation 59.9 seconds) was equivalent to the 11-25% defoliation category (impact score 1).



Relationship between defoliation impacts and total time spent foraging by goats in the transect area, before (O) and after Survey I (●).



Contour plot showing distribution of impact scores (contour labels) collected within the 200x50m transect area during a) Survey I and b) Survey II.

Spatial impacts

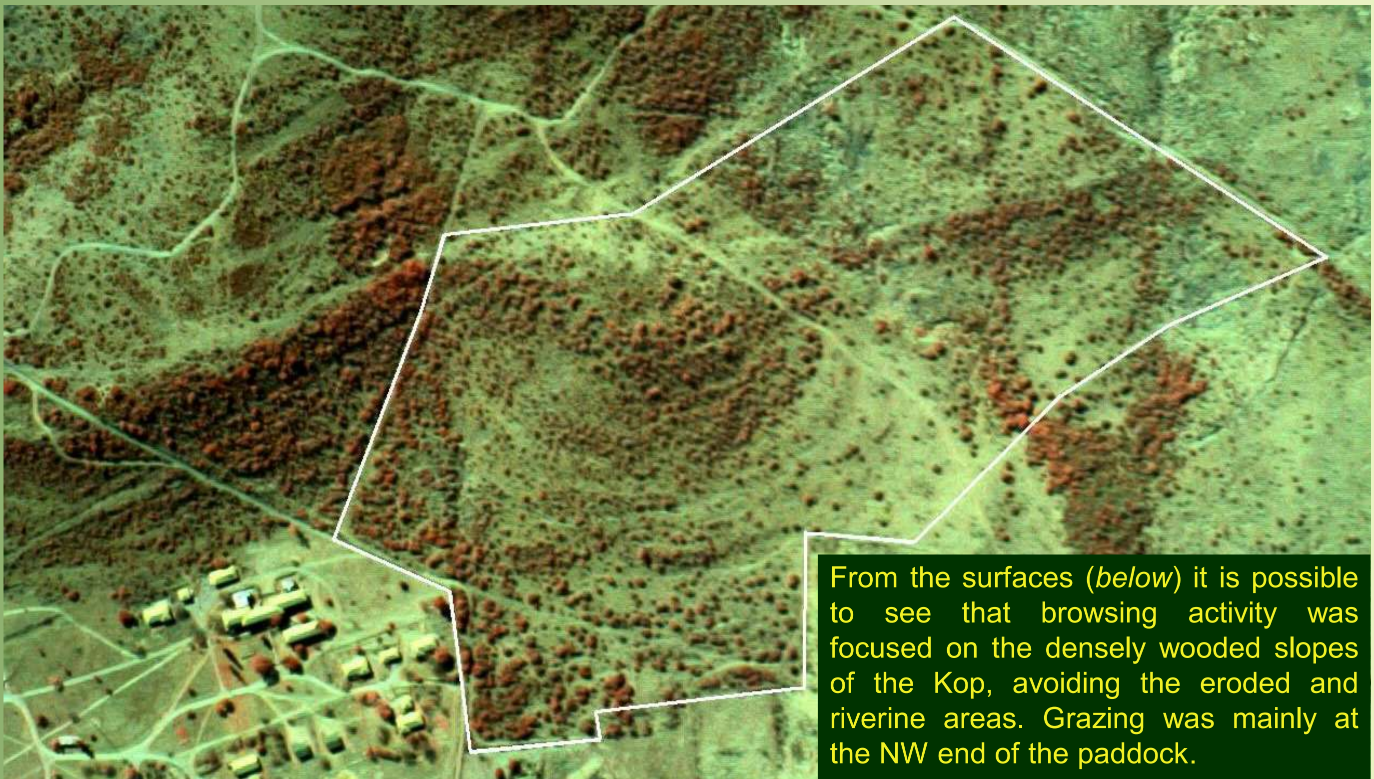
●Analysis of the transect data using a residual maximum likelihood (REML) method showed that tree species within transects were shown to account for most of the variation in impact for either survey ($F=23.68$, df=14, $P<0.001$), and that there was no effect of community association ($F=1.4$, df=3, P=0.23).

●The goats expanded the range for their foraging activity on the slope (from between 0.81m and 174.32m prior to Survey I, to 10.99m and 196.04m afterwards), giving a mean position further up the slope for Survey II both in terms of distance (means=60.5m and 101.7m, $t_{96}=3.53$, $P<0.001$) and altitude (means=540.9m and 549.6m, $t_9=2.89$, $P<0.01$).

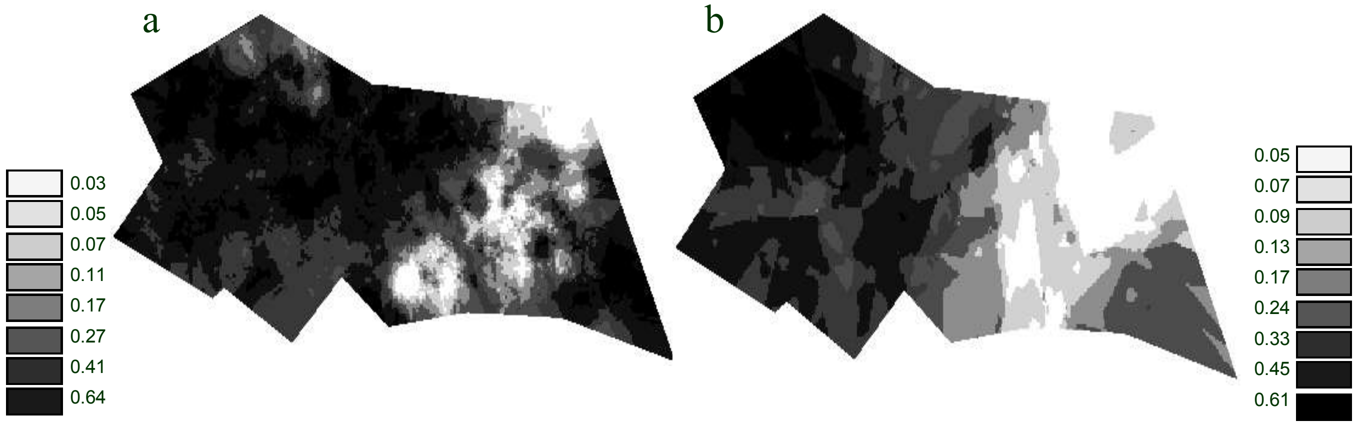
●Diet selection within the transect area, as indicated by the distribution of defoliation impacts between tree species, shifted during the course of the experiment ($F=7.68$, df=14, $P<0.001$).

●Analysis of browsing activity in relation to quadrat composition showed that feeding time was also related to diet species ($F=4.43$, df=44, $P<0.05$). Grazing activity did not (P=0.6). Grass biomass did not differ between surveys ($F=0.19$, df=1, P=0.66).

●Average impacts for each transect were higher in Survey II than Survey I (paired $t_{19}=8.58$, $P<0.001$). Impact scores were higher and appeared to be concentrated higher up the slope in Survey II (*left*).



From the surfaces (*below*) it is possible to see that browsing activity was focused on the densely wooded slopes of the Kop, avoiding the eroded and riverine areas. Grazing was mainly at the NW end of the paddock.



Kriged interpolation of the log of goat activity duration showing the distribution of a) browsing and b) grazing in the paddock. The classes of activity duration range from high (darkest) to neglible (lightest) in minutes per individual.

CONCLUSIONS

The animals responded to the heterogeneity of their resources. Both analyses of transect and quadrat data showed that goat foraging behaviour was affected at the scale of individual tree species. Feeding activity was not related to the identified plant communities. Animal behaviour varied over time, subsequently impacting areas of lower initial defoliation. Consequently, impacts from herbivory appear to be distributed such that they mirror the distribution of the resources. Browsing results in the generation of spatially non-random impact patterns as an response to the local scale, on a tree-to-tree basis. Clumped resources in the landscape give rise to the concentration of foraging activity, and the concentration of defoliation impacts. The spatial character of these impacted regions may not be easily quantifiable, but their visualisation is achievable using geostatistical methods.

Acknowledgements

The authors would like to thank the following for their invaluable help during the experiment. Data collection was by Wellington and his team, including Mweli, MPendu and James who also assisted with GPS measurements. The Departments of Geology and Geography at the University of Fort Hare supplied GPS and surveying equipment and with advice on their use. Tony Palmer provided an aerial infrared photograph of the study site. Nick Colgrave, Trimble Navigation Europe Limited (UK), Optron (SA) and Telkom (SA) contributed towards assessment of the GPS accuracy. Craig Morris and Tony Hunter gave advise on statistical analysis. Hilary Third helped to capture the large volume of data. This work was supported by the UK Royal Society and NRF Link Programme.